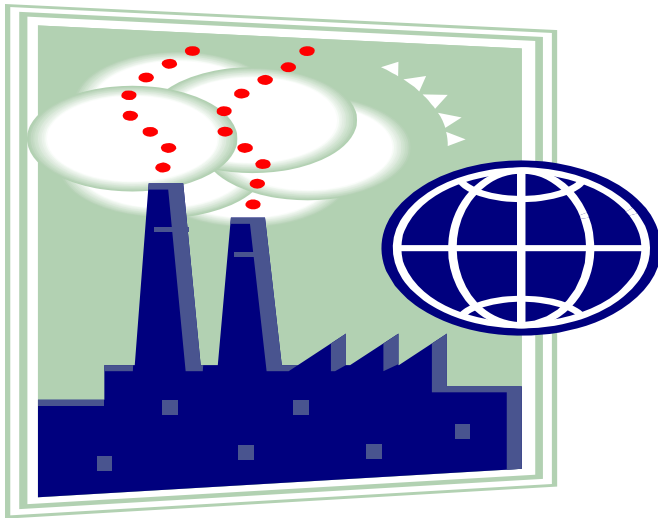# AERMOD Evaluation for Non-Guideline Applications

Roger W. Brode
U.S. EPA, OAQPS
Air Quality Modeling Group
Research Triangle Park, NC
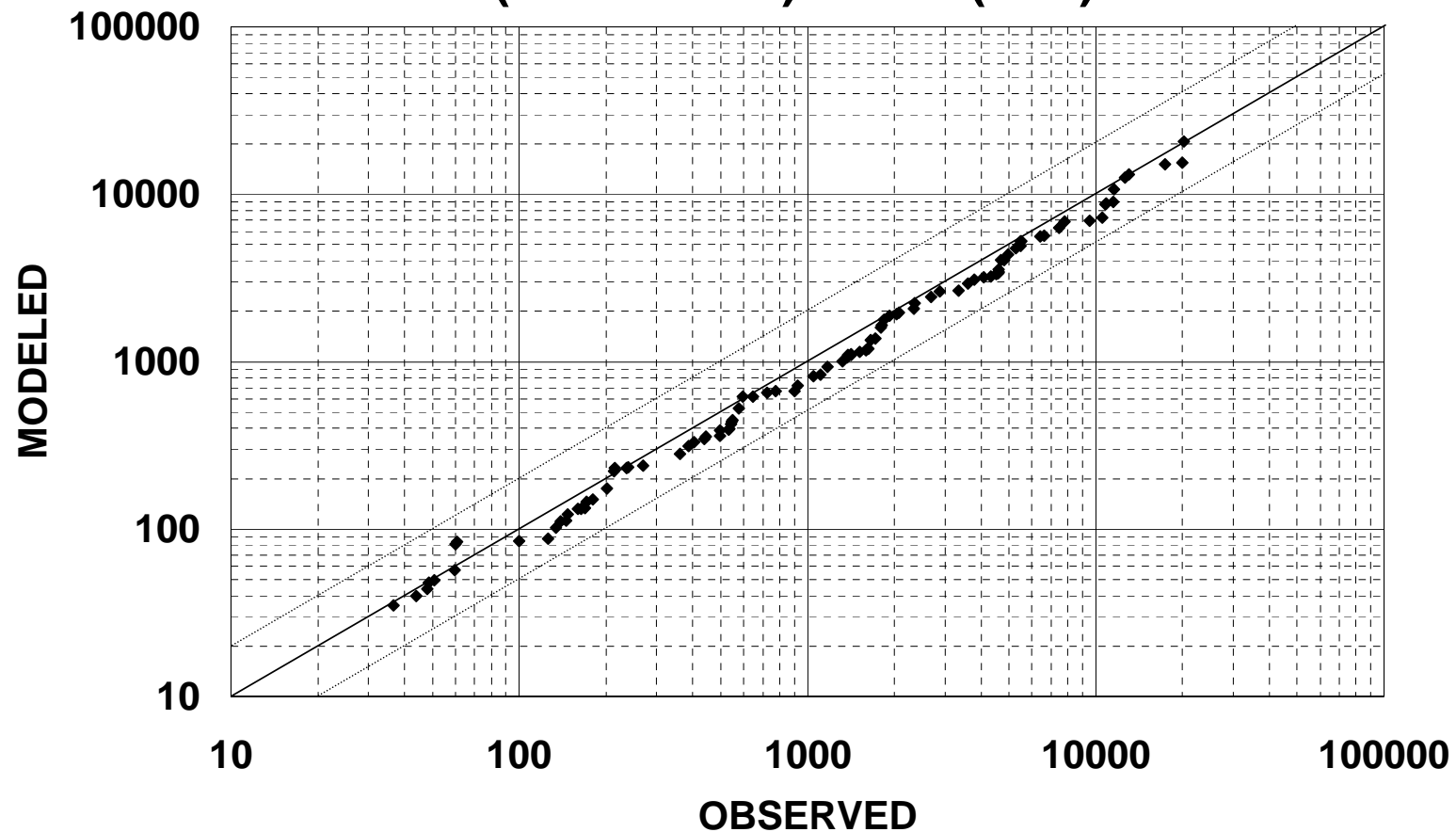
# Requirements of Operational Regulatory Dispersion Models vs. ER Models

- Regulatory models need to predict the peak of the concentration distribution, unpaired in time and space, for comparison to AQ standards

- Emergency response models, and models used for risk and exposure assessments, require skill at predicting concentration distributions paired in time and space

- Growing need for integrated exposure and risk-based approaches to health and environmental impact assessments places higher demands on dispersion model skill that will be difficult to meet

# Example of Operational Regulatory Dispersion Model Evaluation

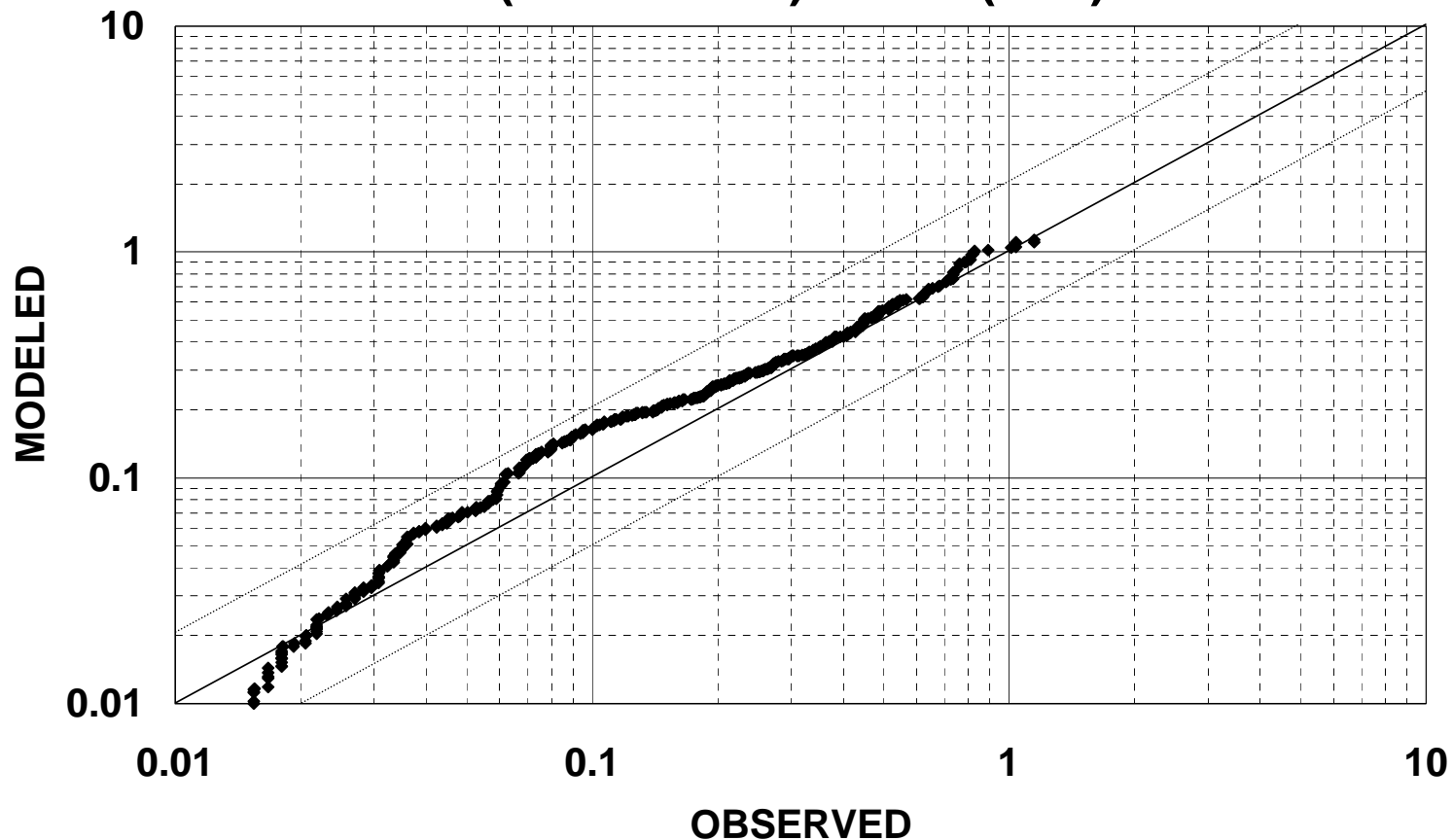

PRAIRIE GRASS - STABLE - AERMOD
Q-Q (UNPAIRED) PLOT (C/Q)

# Previous Example Showing Results Paired in Time and Space



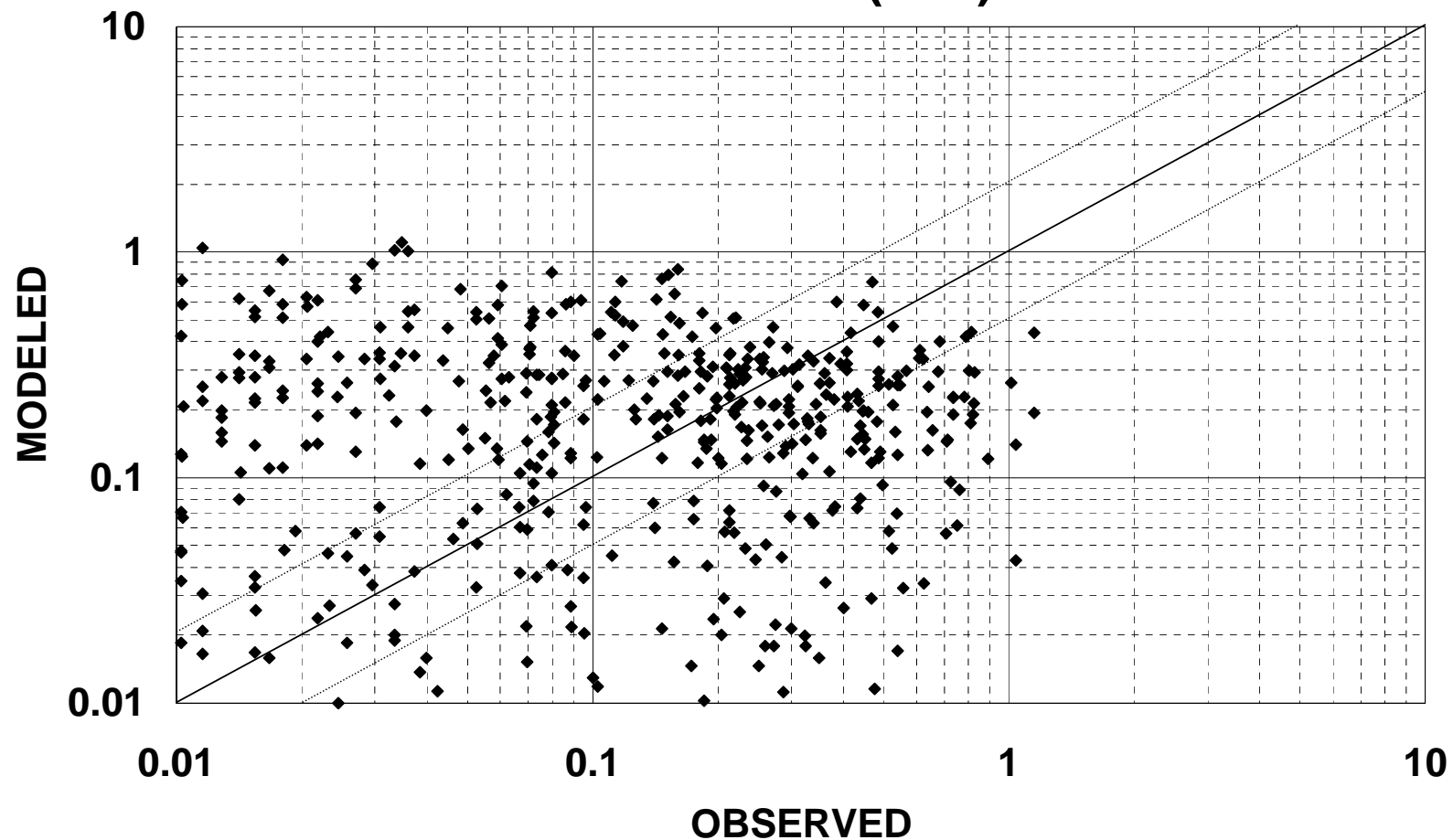PRAIRIE GRASS - STABLE - AERMOD
PAIRED PLOT (C/Q)
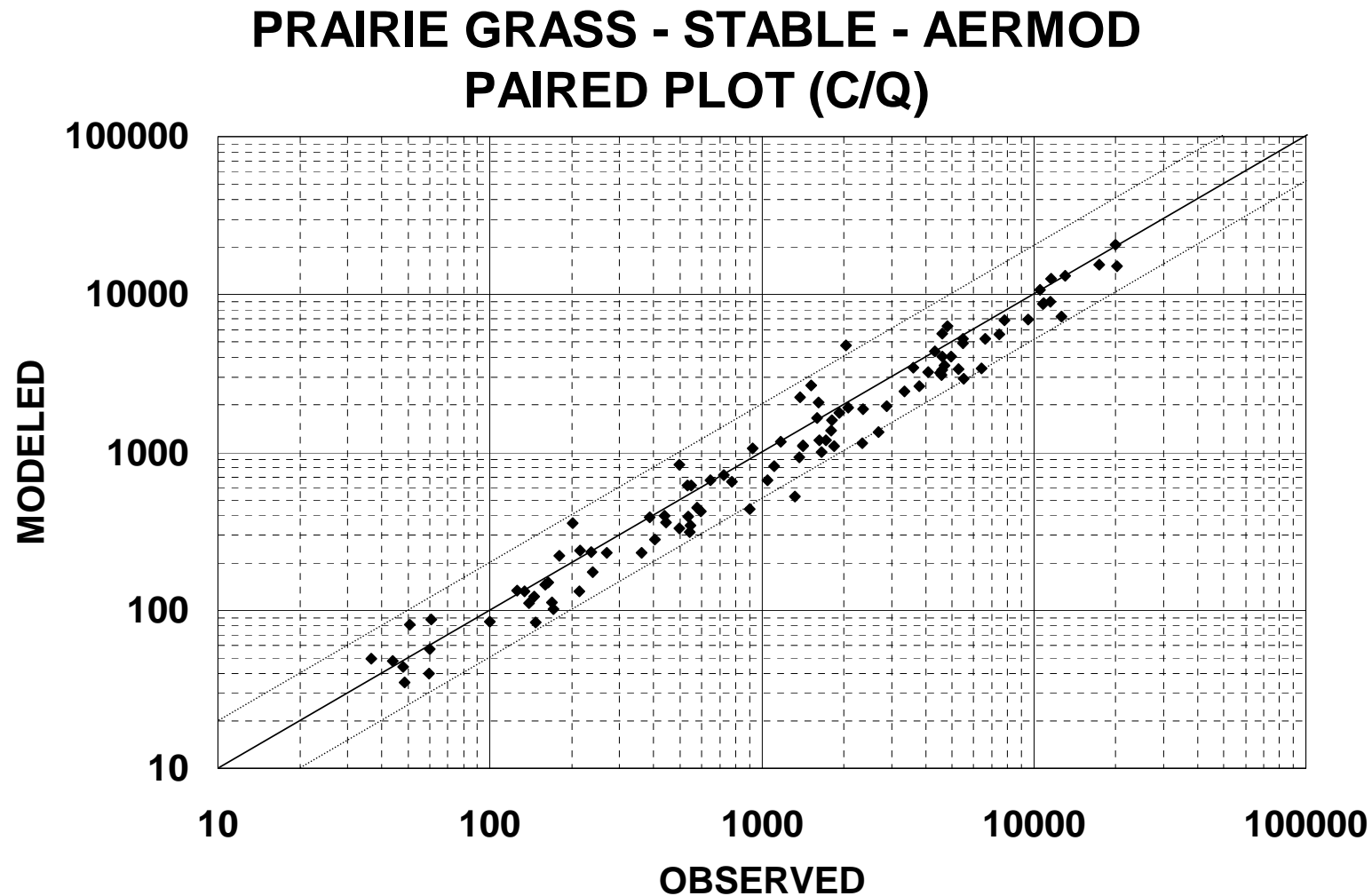
# Example of Operational Regulatory Dispersion Model Evaluation – Urban Case



INDIANAPOLIS SF6 - STABLE - AERMOD
Q-Q (UNPAIRED) PLOT (C/Q)

# Previous Example Showing Results Paired in Time and Space
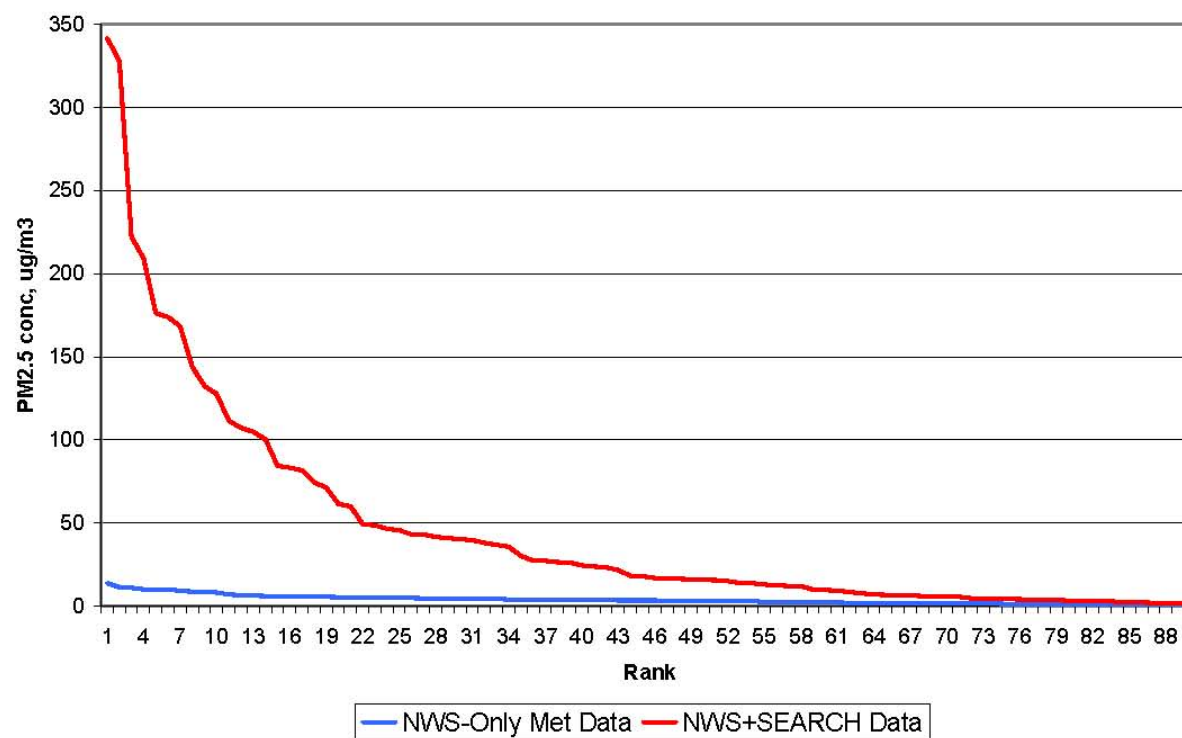


INDIANAPOLIS SF6 - STABLE - AERMOD
PAIRED PLOT (C/Q)

# AERMOD Low Wind Speed "Issue"

# Example from Birmingham LAA

- Contacted by AL DEM regarding use of AERMOD for Birmingham Local Area Analysis (LAA) for PM-2.5 SIP

- CMAQ used for regional scale secondary PM-2.5

- AERMOD used for LAA of primary PM-2.5; results used to determine Relative Reduction Factors (RRFs)

- Concerns expressed regarding unrealistically high concentrations from AERMOD using SEARCH met data with low threshold sonic anemometers (about 0.1m/s)

- Initial results (following two slides) reflected maximum modeled concentration across receptor grid, including receptors near fenceline of modeled source
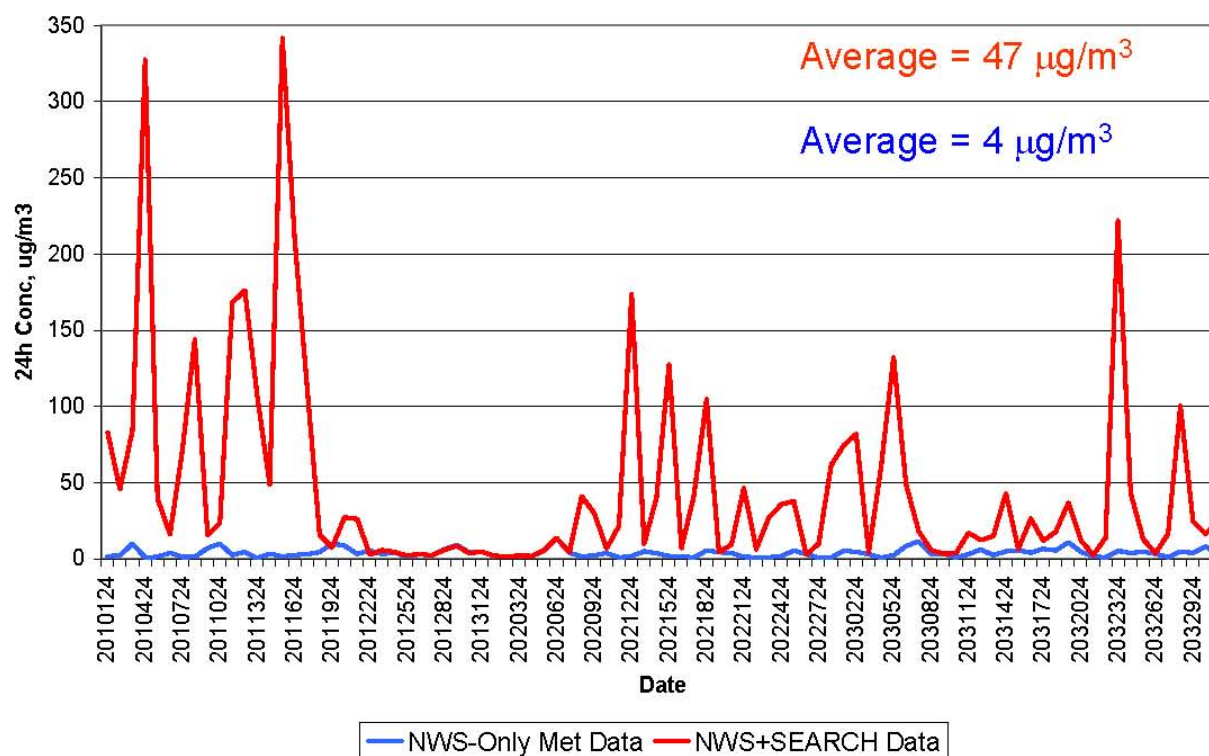
# AERMOD Issues

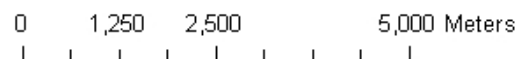**24 hour PM2.5 at WYLM, 1st Quarter max receptor**

# AERMOD Issues

**24 hour PM2.5 at WYLM, 1st Quarter max receptor**



Average = 47 $\mu$g/m$^3$

Average = 4 $\mu$g/m$^3$

Legend: NWS-Only Met Data — NWS+SEARCH Data

Birmingham land cover (NLCD 92)

Legend

| | |
|---|---|
| | 11 |
| | 21 |
| | 22 |
| | 23 |
| | 31 |
| | 32 |
| | 33 |
| | 41 |
| | 42 |
| | 43 |
| | 81 |
| | 82 |
| | 85 |
| | 91 |
| | 92 |

N

SEARCH

Airport

0    1,250    2,500         5,000 Meters
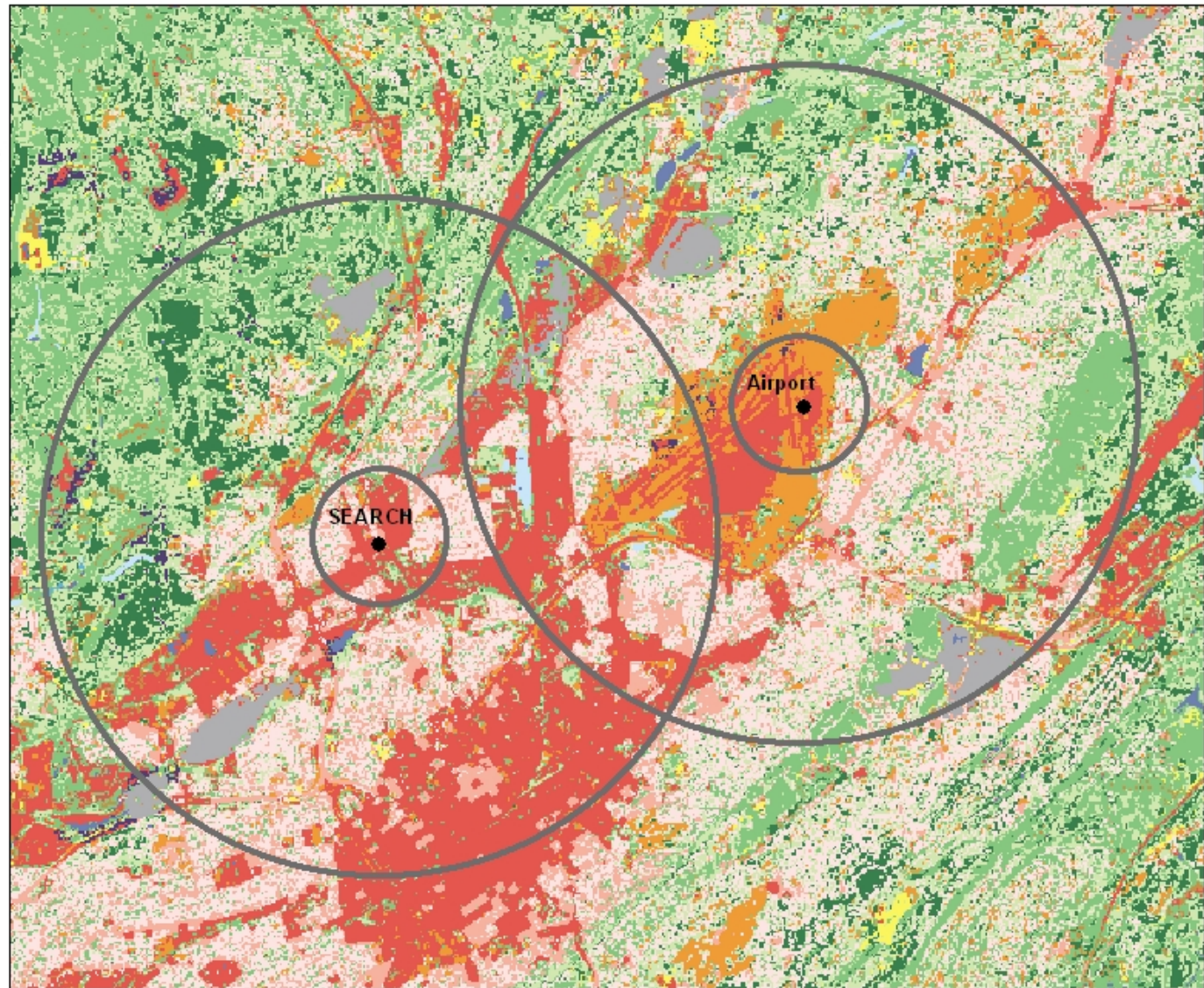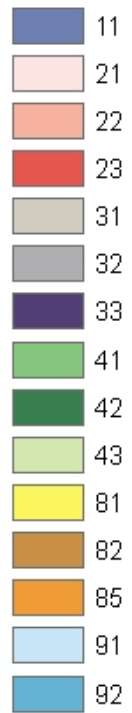
# Example from Birmingham LAA

- Time series of modeled vs. monitored concentrations on the next slide shows strong correlation between high monitored concentrations and high number of calm hours in the airport met data

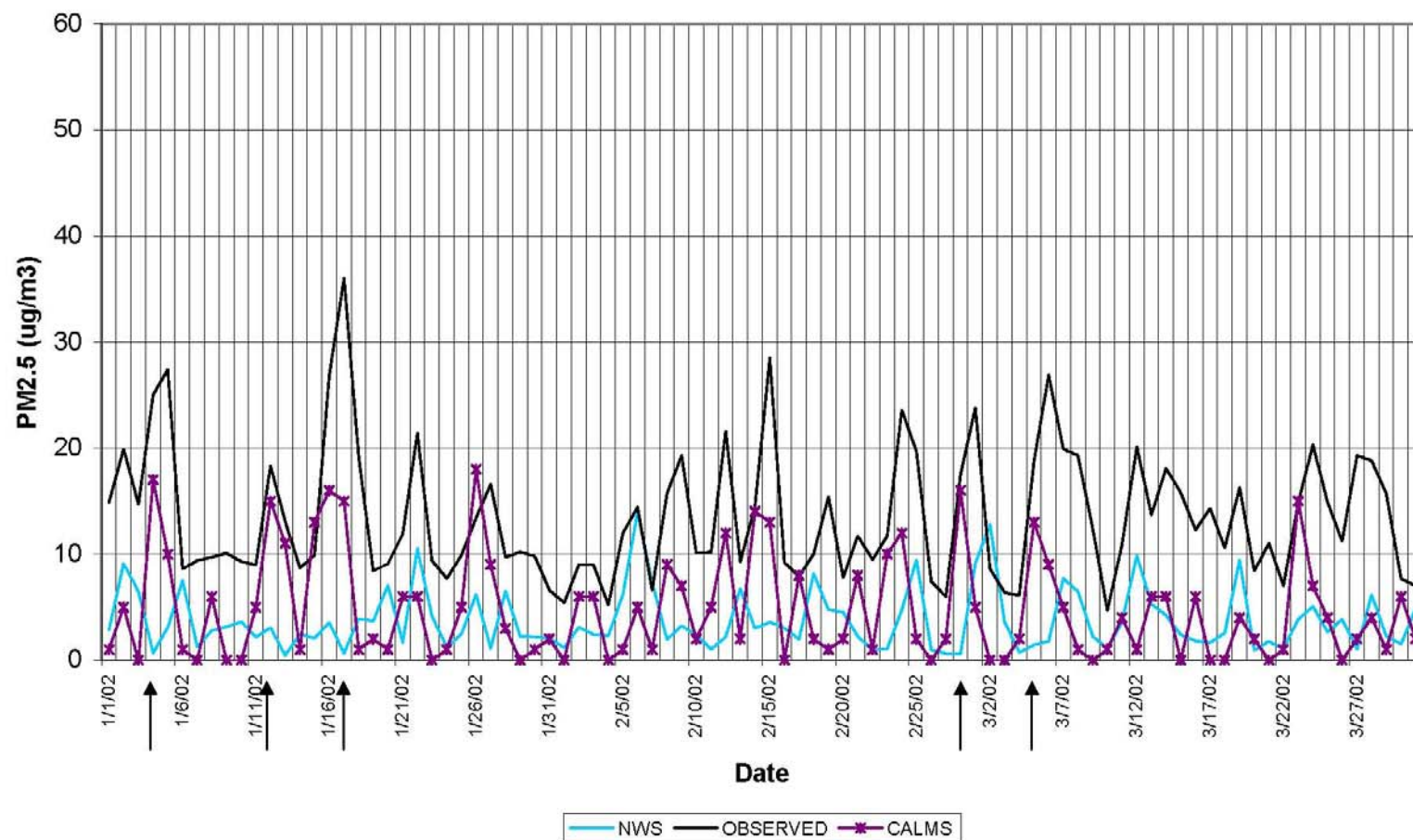- Modeled concentrations with standard NWS met data shows negative correlation on days with high number of calms

- These results suggest potential impacts from local low-level sources of PM-2.5

# NBHM PM2.5 - AERMOD PREDICTIONS VS. OBSERVED - LIGHT WINDS IMPACT STUDY (QTR1)

# Example from Birmingham LAA

- Localized low-level drainage flows under light wind/stable conditions may be affecting model performance:
  - SEARCH met data (collocated with ambient monitor) shows low-level drainage winds mostly from northerly direction
  - BHM NWS met data, supplemented with 1-min ASOS winds shows low-level drainage winds mostly from easterly direction, generally toward monitor from nearest modeled source

- High modeled concentrations based on SEARCH met data for first three weeks of January 2002 also suggest importance of low-level drainage flows
  - SEARCH winds found to be misaligned by 120 degrees for this period, altering direction of drainage winds
  - Note that results for period from 01/25 to 02/08 are based on NWS data since SEARCH data were missing

**Birmingham, AL elevations**
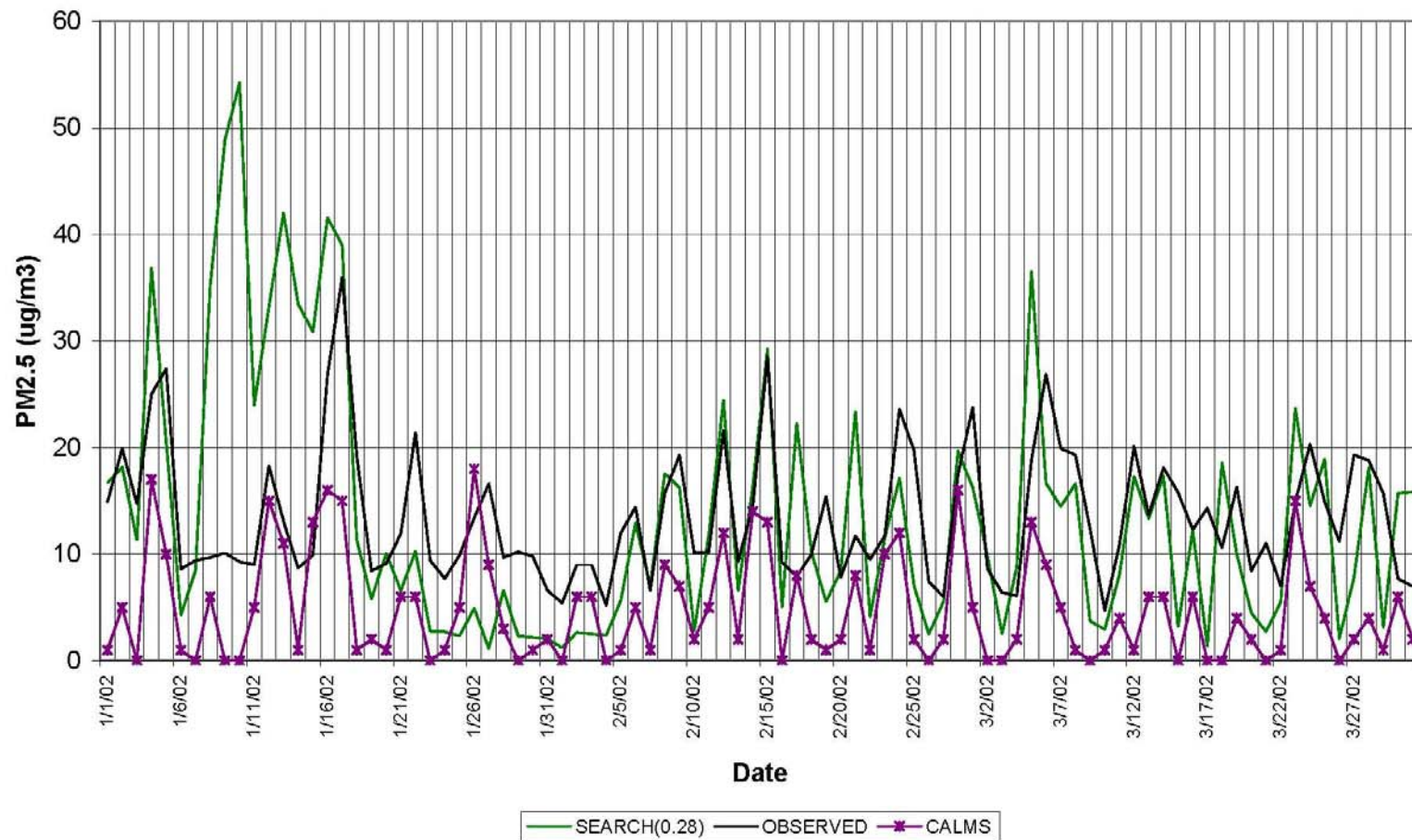
Elevations (m)

High : 380.148

Low : 123.87

Airport

SEARCH site
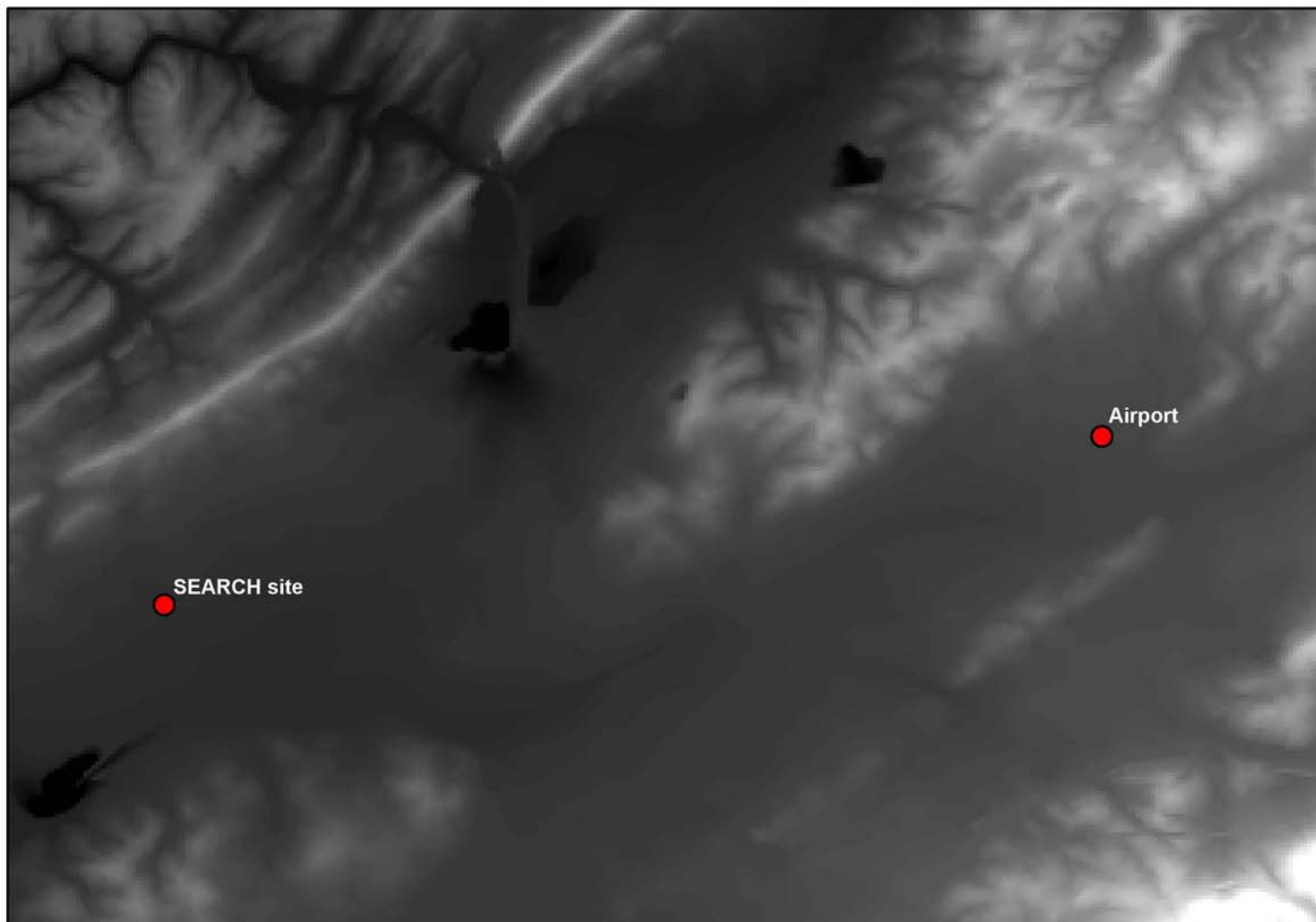
0   0.5   1        2 Kilometers

NBHM PM2.5 - AERMOD PREDICTIONS VS. OBSERVED - LIGHT WINDS
IMPACT STUDY (QTR1)

SEARCH(0.28) —— OBSERVED ✳ CALMS

# Surface Roughness Sensitivity

# Example from NO$_2$ NAAQS Review

- AERMOD being applied to support exposure assessment for the Atlanta area to support current NO$_2$ NAAQS review

- Majority of NO$_2$ impacts attributed to mobile sources

- Initial model-to-monitor comparisons showed AERMOD concentrations significantly exceeding monitored NO$_2$ concentrations at 3 Atlanta monitors

- Initial assessment was that low surface roughness used to process airport data was not representative of roughness typical of source locations, and suggestion was to re-process airport data with 1m roughness

# Example from NO$_2$ NAAQS Review

- Based on a broader assessment of modeling analysis, recommendations were made to
    - Acquire and process SEARCH met data as more representative of surface characteristics for mo
    - Apply OLMGROUP option within Ozone Limiting Method to better account for NO to NO$_2$ conversion
    - Modify source characteristics for mobile source emissions to better account for vehicle induced turbulence
- Next slide shows a land cover map with locations of Jefferson Street SEARCH site (JST) and Atlanta Hartsfield airport site (ATL)

## Legend

- ◼ Open water
- ◻ Low intensity residential
- ◼ High intensity residential
- ◼ Commercial/industrial/transportation
- ◻ Bare rock/sand/clay
- ◻ Quarries/strip mines/gravel pits
- ◼ Transitional
- ◼ Deciduous forest
- ◼ Evergreen forest
- ◻ Mixed forest
- ◼ Pasture/hay
- ◼ Row crops
- ◼ Urban/recreational grasses
- ◻ Woody wetlands
- ◼ Emergent herbaceous wetlands

N

JST

ATL

0   1,250 2,500      5,000  Meters
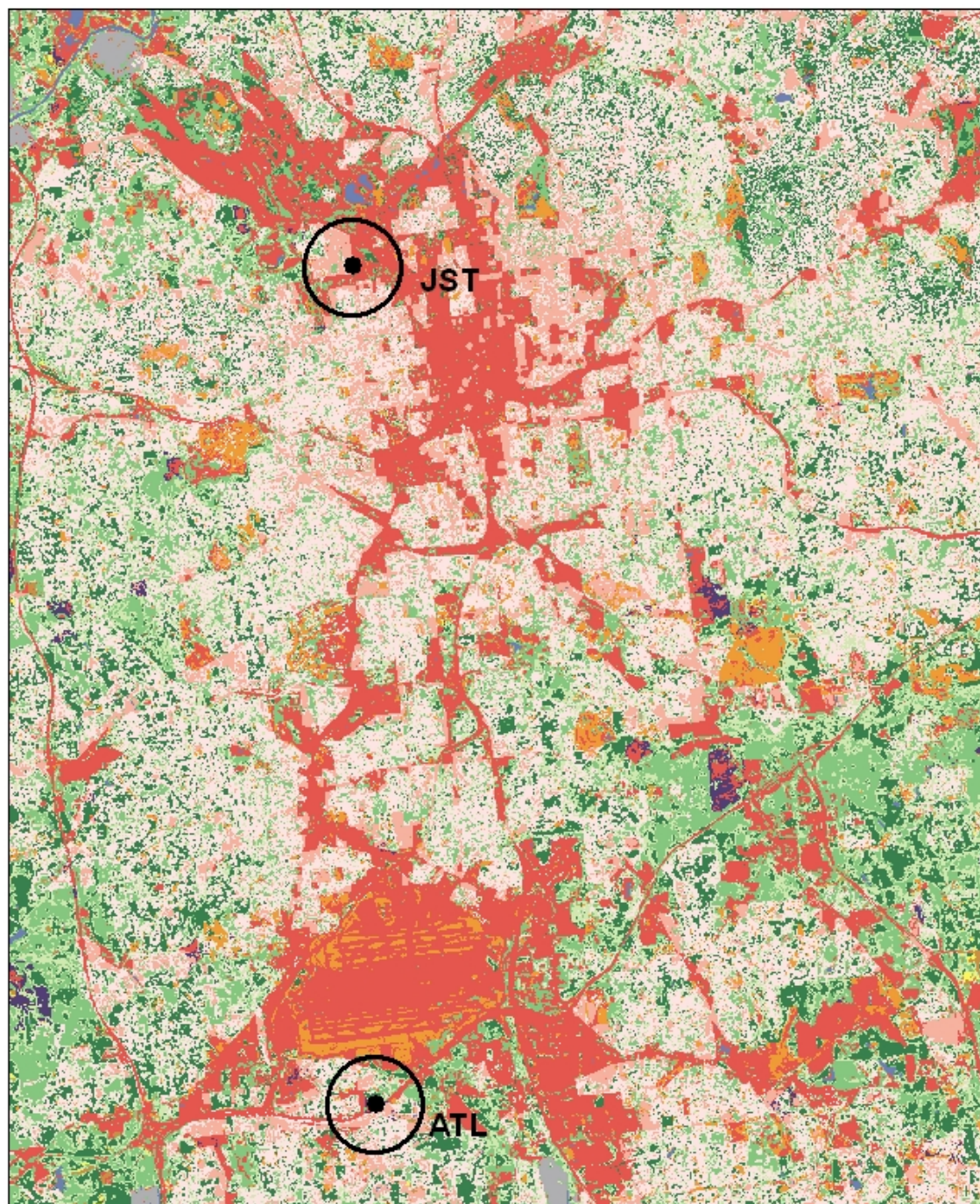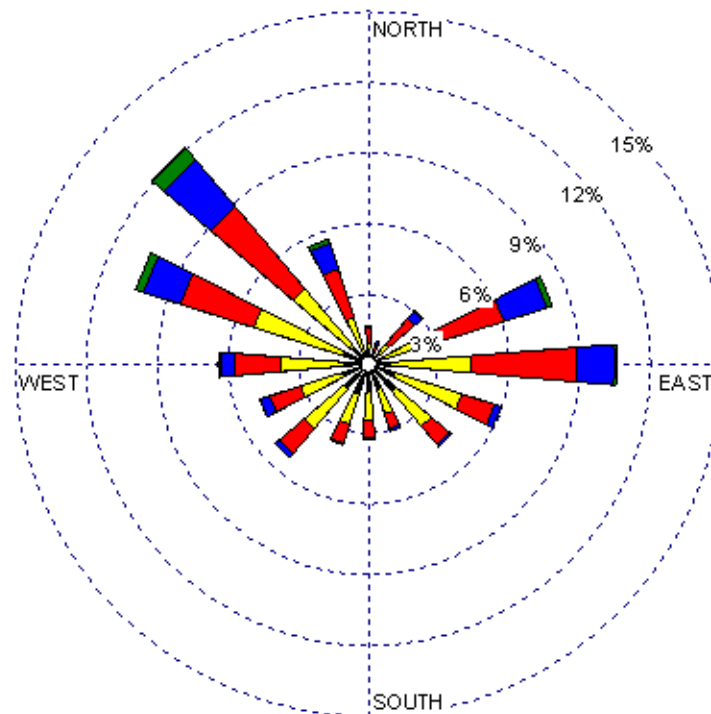
Wind Rose Comparison for SEARCH and ATL-NWS
Data for 2002
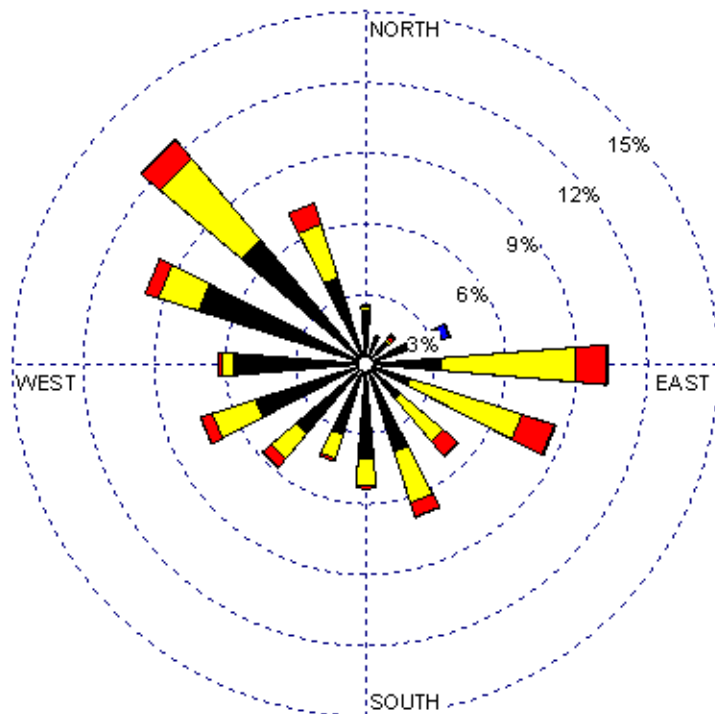
# Model-to-Monitor Comparison - Before



NO2 concentrations at monitor 131210048 (black line) and AERMOD
predictions at an off−road receptor 50 meters from the monitor (blue line)
Receptor id: 00000417.60001_00002489.92993
(AERMOD simulation with onroad mobile source emissions only)
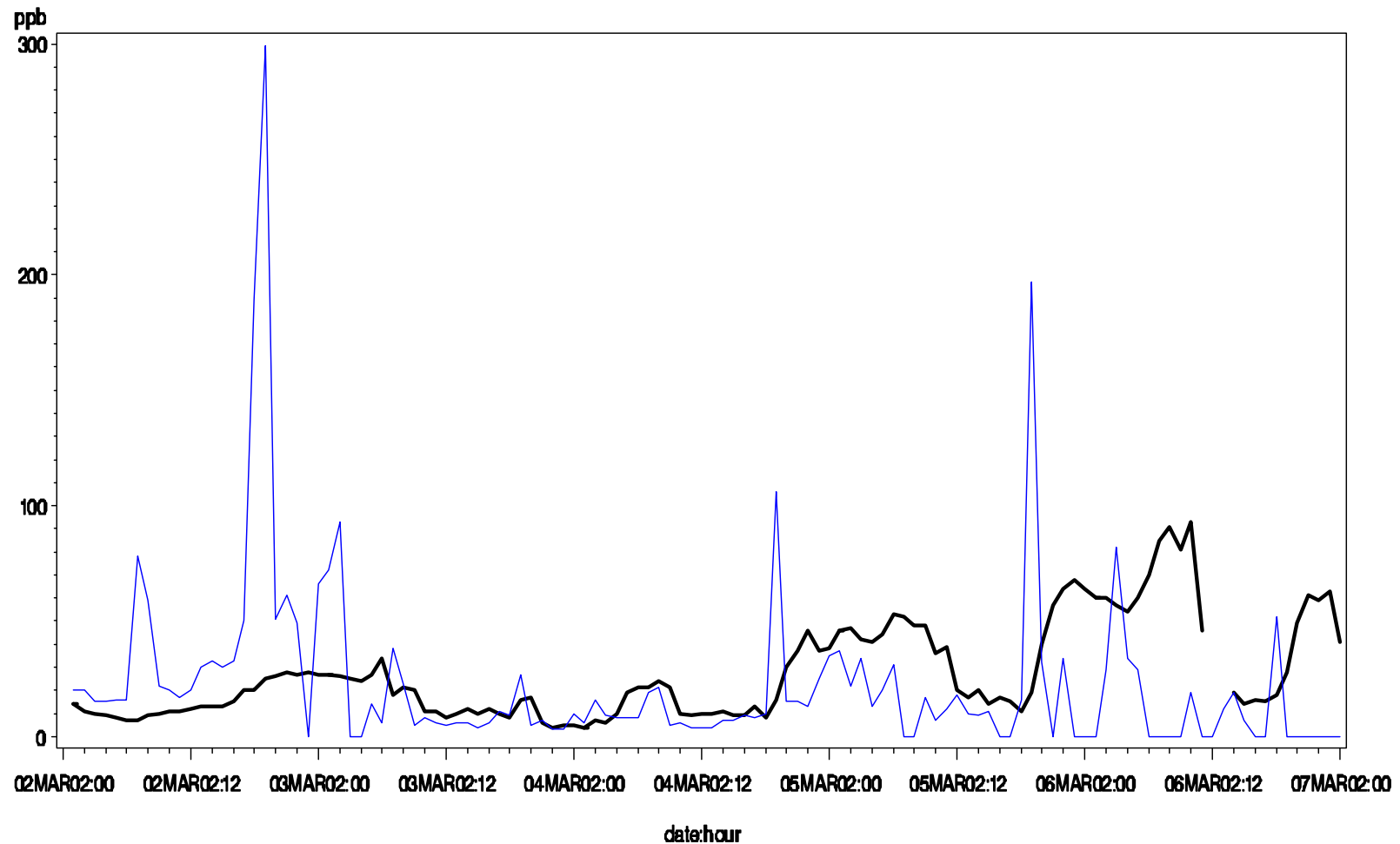
# Model-to-Monitor Comparison - After

month=3
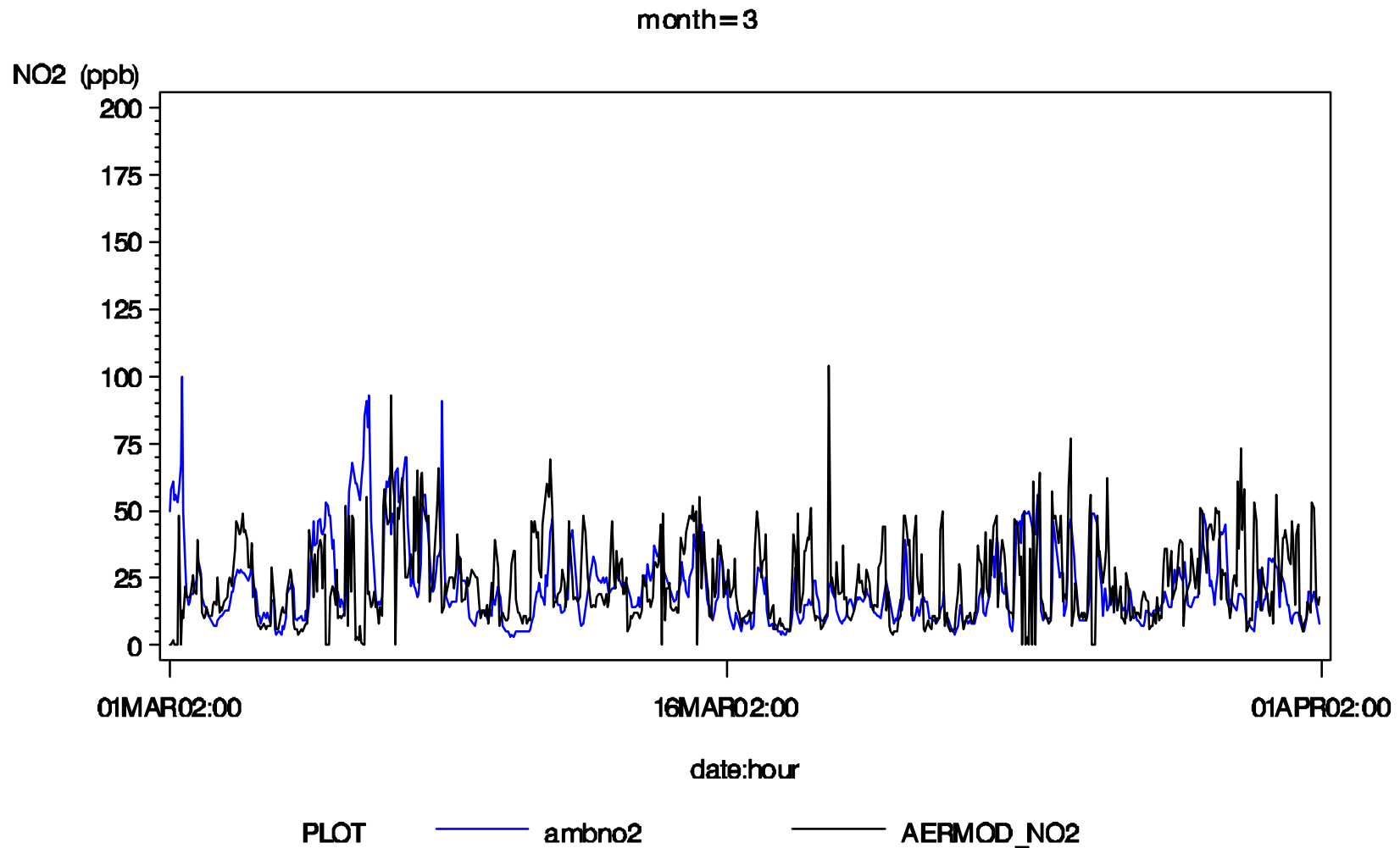
# Q-Q plot of modeled concentrations using SEARCH (JST) vs. NWS (ATL) data

**Atlanta NO2 1-hr CONC Q-Q Plot, JST vs ATL Met, 2002**

# Source Characterization Issue

# Example from Benzene RTR

- Model-to-monitor comparisons of Benzene concentrations from Texas City refineries for residual risk review
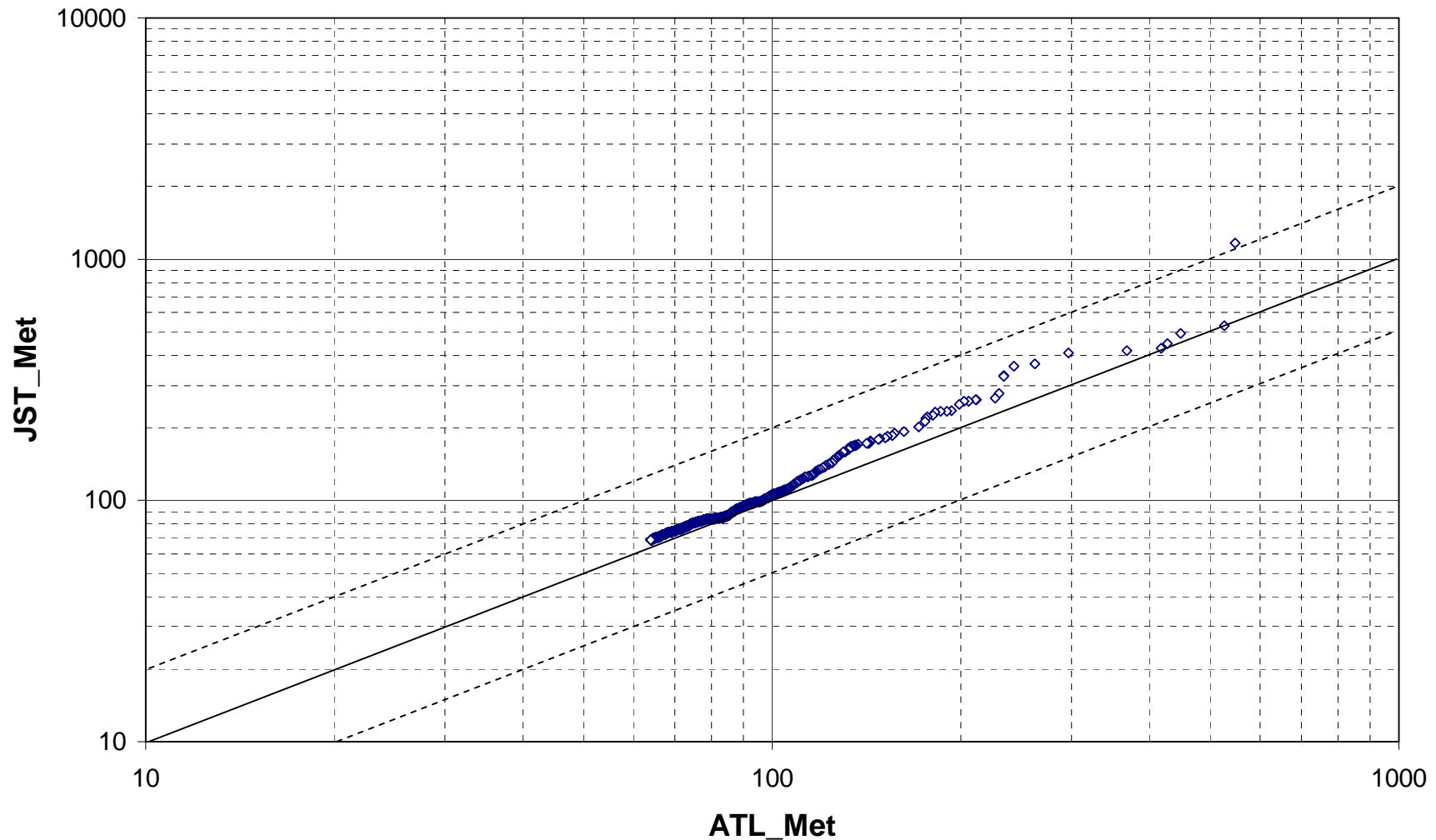
- Initial results from standard ISHD airport data showed significant underpredictions

- Recommended using 1-minute ASOS wind data to reduce number of calms, which contributed to underprediction

- More detailed assessment of representativeness of met data resulted in selection of another nearby station

- Sensitivity of model results to source characterization options for storage tanks examined, with recommendations to improve characterization

**Source Characterization Options for Storage Tanks in AERMOD**

Legend:
- point h=10m (with building)
- point h=10m (no building)
- area (h=10m, sigmaz=0)
- circle (h=10m,sigmaz=3.4
- circle (h=7m,sigmaz=3.5
- volume (h=7m, sigmay=5, sigmaz=3.5)

Y-axis: Concentration (ug/m^3)
X-axis: Downwind Distance (m)
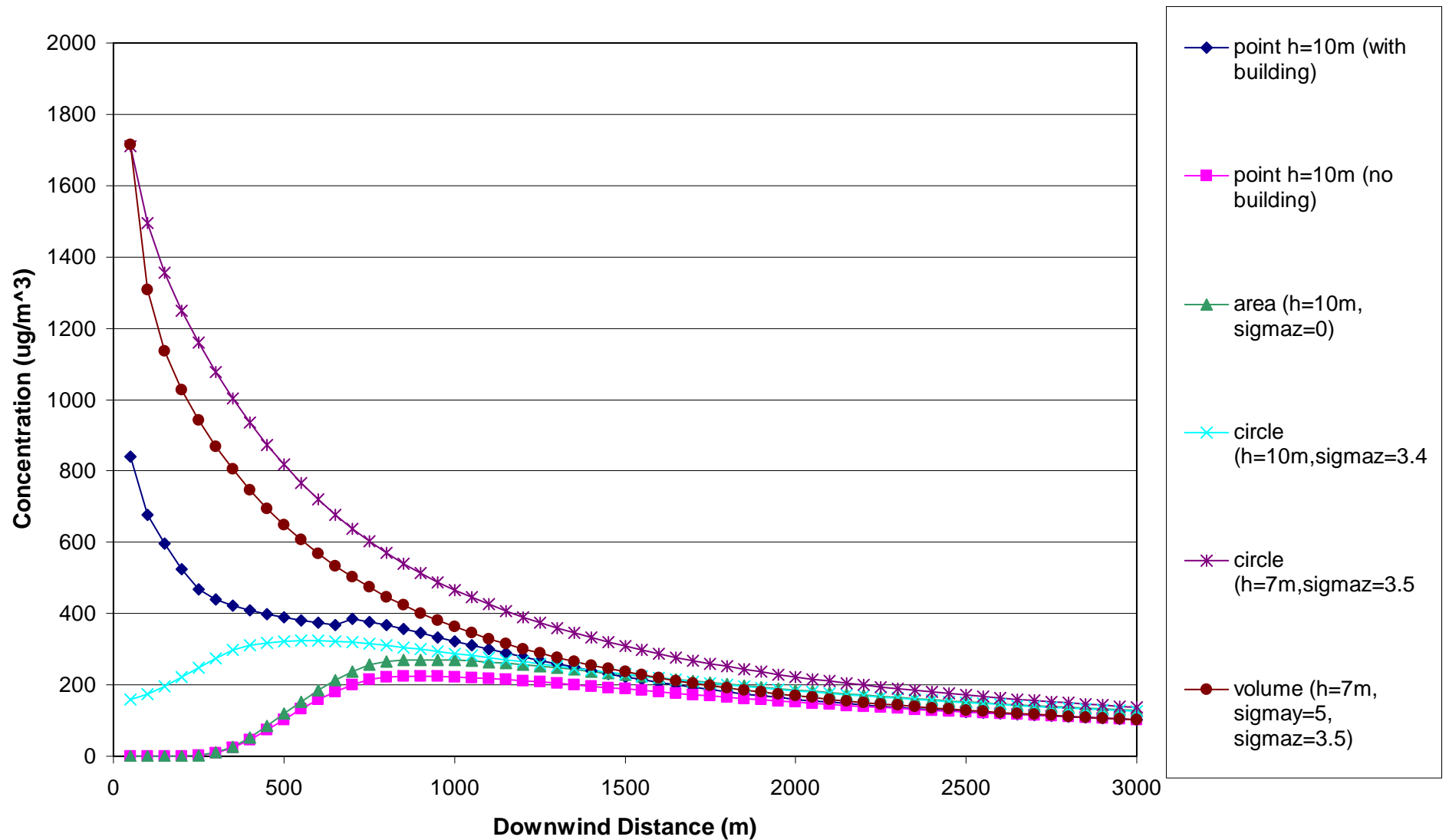
# Results for Benzene Model-to-Monitor Comparisons at Texas City

| Met data | BP (5.65) | | | | | Marathon (6.7) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | h=10m,sigma z=0 | | h=5m,sigma z=2.3 | | volume (h=7,sigmay=5, sigmaz=3.5) | h=10m,sigma z=0 | | h=5m,sigma z=2.3 | | volume (h=7,sigmay=5, sigmaz=3.5) |
| | rural | urban | rural | urban | rural | rural | urban | rural | urban | rural |
| HOU Std. ASOS | 5.35 | 4.16 | 6.45 | 4.46 | 5.74 | 2.52 | 1.75 | 2.57 | 1.75 | 2.39 |
| HOU Hybrid | 6.99 | 4.97 | 11.86 | 5.28 | 9.22 | 4.05 | 2.12 | 4.83 | 2.13 | 4.04 |
| Ball Park 5 min | 1.72 | 1.73 | 1.81 | 1.77 | 2.03 | 1.17 | 0.88 | 1.19 | 0.88 | 1.44 |
| Ball Park hourly | 1.72 | 1.78 | 1.92 | 1.81 | 2.32 | 1.17 | 0.90 | 1.20 | 0.90 | 1.61 |
| GLS Std. ASOS | 3.66 | 3.79 | 5.52 | 4.29 | 4.74 | 2.45 | 1.97 | 2.66 | 1.98 | 2.32 |
| GLS Hybrid | 3.61 | 3.84 | 5.96 | 4.32 | 5.02 | 2.70 | 2.11 | 3.12 | 2.12 | 2.64 |

- Results based on Galveston (GLS) met data and simulation of tanks with h=5m, sigma-z0=2.3m show good agreement for BP monitor

- Results for Marathon monitor underpredict for all cases shown; other background sources may be contributing given location of monitor relative to modeled inventory